WATER QUALITY OF LAKES IN THE SEVEN LINKS PLANNING AREA

PETERBOROUGH COUNTY

1979

PART 1

Ministry of the Environment
Ontario

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WATER QUALITY SURVEY OF LAKES
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Field Survey 1978
Report 1979

Report Prepared by: Technical Support Section
Central Region

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INTRODUCTION

In early 1978, the Seven Links Planning Board requested the assistance of this ministry in conducting water quality surveys of the major lakes in the planning area. A joint program was arranged with the Planning Board supplying field staff hired under a Canada Works Grant, rental truck, field lab and office facilities. The MOE Central Region Office supplied a staff member to oversee the sampling program and report writeup. Sampling equipment and analyses of chemical and biological samples were also provided by MOE. The purposes of the sampling program were to:

1. define the water quality status of the major lakes in the planning area;

2. give some indication of the sensitivity of each lake to further shoreline development;

3. provide this information to the planning board (in the form of a publically released report) to assist them in making planning decisions on lakeshore development.

   The report format is divided into two parts. Part 1 provides an outline of the study area, procedures and recommendations. Part 2 is a compilation of individual lake reports that include specific data for each lake.

DESCRIPTION OF THE STUDY AREA

The Seven Links Planning Area is located in the southeastern corner of Peterborough County. It includes the Townships of Asphodel, Belmont, Dummer and Methuen as well as the Villages of Hastings, Havelock and Norwood. Seventeen Lakes and the Trent River were chosen for study (Figure 1). Because the political boundaries cut through some lakes it was necessary to collect data from locations outside the planning area for a meaningful understanding of the lake water quality.

A total of thirty-eight routine lake sampling stations were chosen to provide representative water quality of the various lake basins and/or bays. Moreover, routine stream sampling stations were established at inflows of appreciable flow and at the outflow from each lake. Additional sampling points were established when specialized sampling was required. All sampling locations for each lake are shown in the individual lake reports contained in Part 2.

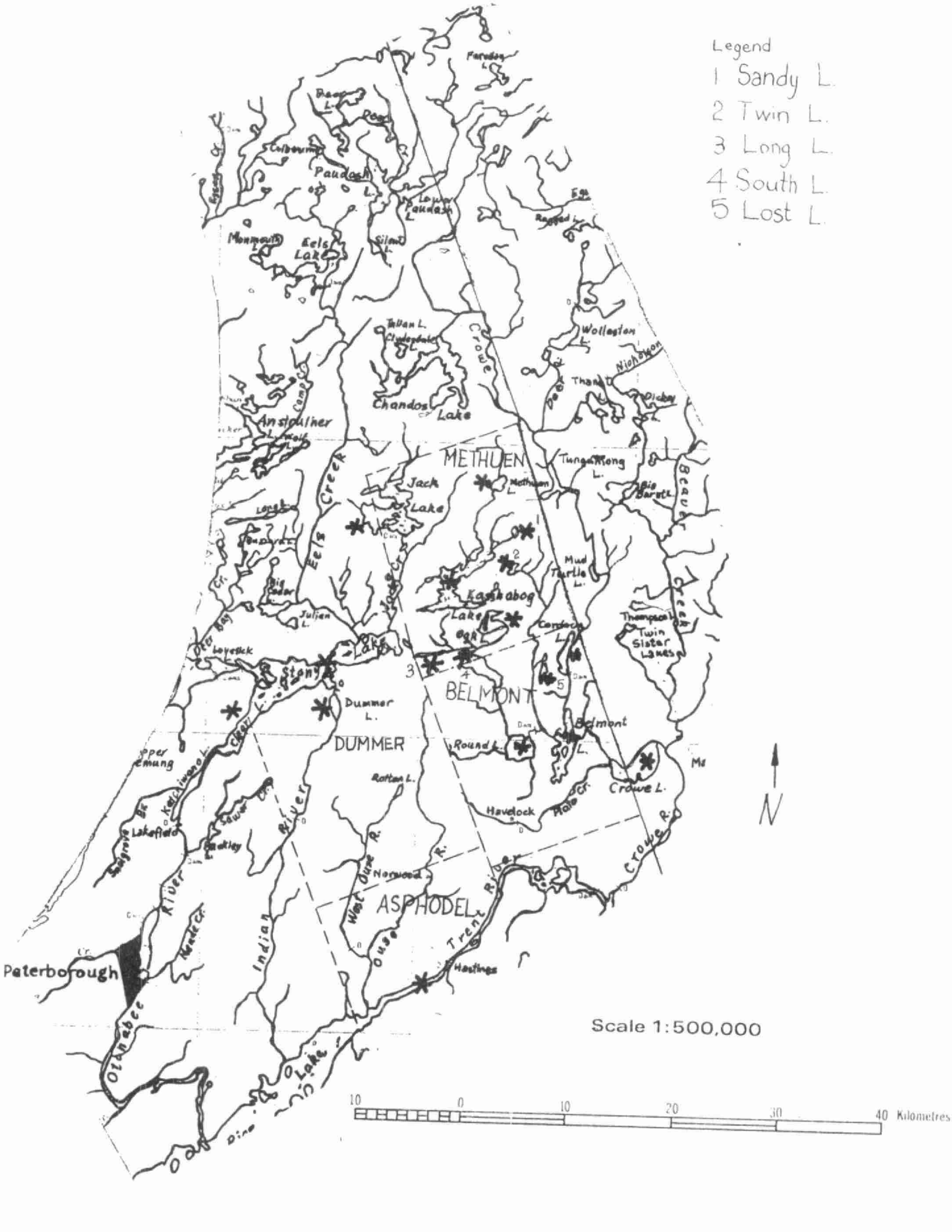
The Planning Area is situated in a transition area between Pre-Cambrian Shield bedrock and sedimentary bedrock. Overburden is generally thin in the northern portion of the area with frequent bedrock outcroppings. In the southern portion, overburden is generally deeper with poorly to well drained soils.

Two major flow systems in the Planning Area are the Crowe River and the Trent River. Jack Lake, Dummer Lake and Stony Lake are part of the Trent System. The other lakes studied drain into the Crowe River system via either the North River or the Crowe River.

The Crowe River system is controlled by several dams operated privately or by the Crowe Valley Conservation Authority. The dams regulating flow at Jack Lake, Dummer Lake, Stony and Clear Lakes and the Trent River at Hastings are operated by the Trent-Severn Waterway Office of Parks Canada.

The water bodies in the Planning Area receive a wide range of uses including: swimming, boating, canoeing and fishing. Many of the water bodies were used as agricultural and domestic water supply sources. Lake shoreline development is outlined in the individual lake reports. The Trent River had heavy cottage development on both sides of the River as well as the Village of Hastings which has a population of about 1200.

Figure 1: Planning Area Lakes Studied And Their Drainage 1978



✱ Lake Studied During 1978

SURVEY PROCEDURES

Sampling

Seven "complete sample runs" were conducted at each lake station through the ice-free period of 1978. During each run the following took place:

a) Lake temperature profiles were obtained using a calibrated marine telethermomether (Hydrolab Corp. Model (FT-3M)). Stream temperatures were taken with a standard laboratory thermometer. Dissolved oxygen (D.O.) concentrations through the water column at the lake stations and stream stations were determined using the azide modification of the Winkler method.

b) Water clarity was measured using a Secchi disc. (30 cm diameter disc divided into alternative black and white quadrants).

c) Samples for general water chemistry, chlorophyll a and phytoplankton were obtained as composites at lake stations through the euphotic zone (calculated as twice the Secchi disc depth) during the ice-free period of the year. This was accomplished by lowering and raising a one litre bottle through the predetermined depth at a rate that allowed complete filling just as the bottle was lifted out of the water. The nutrient chemistry samples were taken in plastic bottles and immediately stored on ice. One litre glass bottles were taken for other chemistry. The chlorophyll a sample was taken in a one litre glass bottle and preserved with 2 drops of a 10% suspension of $MgCO_3$. The phytoplankton sample was also taken in a 1 litre glass bottle and preserved with lugol's solution.

d) Samples for water chemistry were taken one meter off the bottom at lake stations using a Van Dorn bottle, and at the inflows and outflow using either a sample bucket or composite can.

e) Crustacean Zooplankton were sampled using a 12 cm diameter Wisconsin style plankton net with a No. 10 mesh, towed vertically through the water column from 20 meters or one meter off bottom (whichever came first) to the water surface. The contents of the net were washed into a 4-ounce glass jar and perserved with 5% formalin.

"D.O. runs" were conducted between each complete run to sample selected lake stations where thermal stratification was found. Sampling on these runs consisted of D.O. and temperature profiles, Secchi disc measurements and chlorophyll a samples.

In addition to the above routine sampling the following specialized sampling was carried out.

a) Benthic invertebrate samples were taken from the deeper areas in each lake during early summer and fall. An Ekman dredge (23 cm x 23 cm) was used to obtain the sediment samples which were then sifted through a screen bucket with about 0.65 mm mesh aperture. Invertebrates were "picked" from the retained debri using white enamel trays and preserved in 5% formalin. Benthic invertebrates were identified and enumerated at the MOE Central Region office. Identification of midges was taken to genus according to Mason (1973). Segmented worms were identified according to Brinkhurst and Jamieson (1971). All other identifications were done according to Edmondson (1957).

b) Aquatic plants were sampled from each lake to construct a list of common species. On those lakes found to have extensive weed beds, 0.25 m^2 quadrat samples were obtained for dry weight and plant tissue analysis. Moreover, an approximately circular area with a circumference of 18 m was roped off and species composition for the area was obtained using SCUBA. Plants were identified with the assistance of staff of the Limnology and Toxicity Section, Water Resources Branch.

Chemical analyses performed on each water sample included total phosphorus, free ammonia, total Kjeldahl nitrogen, nitrite, nitrate, pH, conductivity. In addition to the above, analyses were also done three times during the survey for: hardness, alkalinity, total organic carbon, total inorganic carbon, colour, turbidity and major ions.

All analyses of water samples were performed at the MOE lab using standard laboratory methods of the Water Quality Section, Laboratory Services Branch.

Phytoplankton samples were identified and enumerated by staff of the Limnology and Toxicity Section, Water Resources Branch.

Hydrology

Data from two continuous recording stations were used to estimate flows in the planning area during 1978. Station 02HK006 on Beaver Creek near Marmora and Station 02HK003 on the Crowe River at Marmora are operated by the Federal Government.

Mean yearly flow for Station 02HK006 was subtracted from flow for Station 02HK003 to obtain the mean flow for the outlet of Crowe Lake. This value was proportioned on a drainage area basis to estimate yearly discharge at the outlet of each lake in the study. Where drainage area was less than ten times the lake surface area, an addition of flow from net precipitation was made according to a method outlined by Dillon (1975). Because the major inflow to Dummer Lake was from a control dam, flow was calculated as in Appendix I.

To estimate monthly discharge for 1978, the proportionate values for Crowe Lake outlet were applied to the year discharge as shown in Appendix 2.

Geology

The watershed geology was established using the Ontario Department of Mines map No. 1957b and the Geological Road Map of Ontario (Ontario Ministry of Natural Resources publication).

Forest Cover

The extent of watershed cover, cleared or forested, was determined by using the appropriate Federal Government Topographical Maps scale 1:50,000.

Morphometric Parameters

Values for lake surface area, drainage area, lake volume, mean and maximum depth were obtained from the following sources:

- Crowe Valley Conservation Area Report 1961 Water and Wildlife
- Parks Canada, Trent-Severn Waterway Office
- Ministry of Natural Resources District Offices
- MOE data or measurements

Nutrient Budget

The amount of phosphorus entering the lakes from various sources was calculated as in Appendix 3. The supply of phosphorus from land drainage for lakes with significant upstream lakes was estimated as per Appendix 3.

Areal Hypolimnetic Oxygen Depletion

The rate of oxygen depletion in the bottom waters of the deeper lakes was calculated according to the method discussed in Wetzel (1975) and according to the method of Nicholls (1976). The value shown in the summary tables in parentheses is from Wetzel's method and the value without parentheses is from Nicholl's method.

WATER QUALITY STATUS

In general there was a wide range of water quality conditions in the lakes studied. Details of individual lake water quality can be found by referring to Part 2 of this report. The relative water quality status of the water bodies is indicated in Figure 2.

Figure 2

Relative Water Quality Status of Lakes
in the Seven Links Planning Area 1978

Methuen		Oligotrophic
Kasshabog		
Oak		
Cordova		
Twin Lakes		Mesotrophic
Upper Stony		
Belmont	increasing	
Crowe	enrichment	
Long		
Round		
Jack		
Dummer		
Lost		
South		
Sandy		
Lower Stony		
Trent River		Eutrophic

LAKE SENSITIVITY

The addition of more phosphorus to a lake can have undesireable water quality effects. Some lakes will be more susceptible to these effects than others. The added phosphorus supply from further unrestricted shoreline development may be significant in that undesireable changes in water quality could result from the added input. A lake that is potentially susceptible to water quality degradation from further significant phosphorus input can be termed "sensitive". Factors considered in establishing relative lake sensitivity in this study are outlined as follows.

Lake Morphometry

Small, shallow lakes with small drainage basin may present physical constraints to shoreline development. For example East Twin Lake with its relatively small surface area and depth may present constraints to the recreational uses associated with shoreline development. Water quality problems such as resuspension of sediments and nutrients could result if normal recreational use is pursued.

Lake Flushing Rate

Lakes with high flushing rates are generally more resistent to changes in water quality than lakes with low flushing rates. For example, Cordova Lake with a high flushing rate of over 30 times during 1978 was considered less sensitive to a water quality change brought about by further unrestricted shoreline development than Oak Lake (flushing rate, 0.19 times during 1978).

Nutrient Accumulation in Bottom Waters

Significant increases in the total phosphorus concentration of the euphotic zone of a lake generally result in higher phytoplankton densities. The increased organic matter from these growths may further reduce the dissolved oxygen concentration near the sediments. With further aggravation of bottom water depletion of dissolved oxygen, plant nutrients may accumulate and may be released from the sediments. These nutrients may become available for increased phytoplankton growths in future years.

The presence of nutrient accumulations in the bottom waters of some parts of a lake but not in the entire lake may be a sensitive feature. Moreover, in a lake with an existing D.O. depletion that results in near complete depletion near the sediments, but does not exhibit nutrient accumulation, further significant nutrient addition to the lake may result in such accumulation and deterioration of water quality.

Jack Lake exhibited significant nutrient accumulation at some lake stations, but at Station J7, no accumulation was noted despite relatively low dissolved oxygen concentrations. Similarly in Oak Lake, no accumulation of nutrients was noted in the bottom waters of Station 02 despite the low dissolved oxygen concentrations. Both lakes were considered sensitive to further unrestricted shoreline development.

Dissolved Oxygen Maxima

A maximum in dissolved oxygen concentration in the profile recorded from some of the lakes in the study were probably the result of the production of dissolved oxygen by phytoplankton inhabiting that layer of water. Since the production takes place in the thermocline or upper hypolimnion of the lake water column, it represented an important biological source of dissolved oxygen for the bottom wates. A significant increase in the phosphorus supply to a lake could result in increased phytoplankton density accompanied by decreased water clarity. Decreased water clarity will eliminate phytoplankton species that inhabit the deeper waters resulting in the loss of the biological oxygen source and the further aggravation of dissolved oxygen depletion in the bottom waters.

The south end of Jack Lake and Oak Lake were found to have dissolved oxygen maxima within the thermocline which could be lost with further water quality deterioration.

Index of total phosphorus concentration change

To provide some insight into the relative sensitivity of the total phosphorus concentration in the euphotic zone of a lake, an index was calculated as in Appendix 4. The index basically shows the calculated difference in spring total phosphorus concentration between the calculated concentration for existing conditions and the calculated concentration with the phosphorus supply from 100 more cottages included.

Appendix 5 shows the calculated index for lakes in the Planning Area.

Based on a consideration of the overall water quality status and the above-mentioned factors, where relevant, the water bodies studied were ranked in order of decreasing sensitivity to further unrestricted shoreline development. Three divisions in the list of water bodies were made for the purposes of recommendations for further shoreline development (see Figure 3). As other policies and studies may apply to the lakes in the Planning Area in future, only interim recommendations are made at this time. These recommendations are outlined as follows.

Figure 3 Relative Lake Sensitivity to Further Unrestricted Shoreline Development

Most Sensitive

Sandy
East and West Twin
Oak
Jack
Kasshabog
Lost

Moderately Sensitive

Long
South
Methuen
Upper Stony

Least Sensitive

Round
Dummer
Belmont
Cordova
Crowe
Lower Stony
Trent River

Interim Recommendations

Least Sensitive

No additional restrictions (other than existing by-laws and Health Unit regulations, etc) on shoreline development are recommended for lakes in the least sensitive category. Clearing of vegetation on lots during development, especially between the tile bed site and the shoreline should be minimized.

In the case of Lower Stony Lake and the Trent River, the existing water quality status was poor with respect to swimming use. Many people may find that swimming in these waters during late summer is not a pleasant experience because of aesthetic problems caused by phytoplankton growths.

Interim Recommendations

Moderately Sensitive

Careful siting of septic tank and tile field systems on both registered vacant lots and proposed new development should be carried out by staff of the local Health Unit to maximize the phosphorous retention capabilities of the natural soil and vegetation on the lot.

Fill material used for the installation of tile field systems should be of a reasonably fine nature to encourage the retention of waste materials such as phosphorus.

Clearing of vegetation on lots during development, especially between the tile bed site and the shoreline, should be minimized.

Interim Recommendations

Most Sensitive

Further development around lake shorelines and inflows should be carefully planned to minimize or eliminate added phosphorus input. The following specific recommendations are made:

a) careful siting of septic tank and tile bed systems on vacant registered lots that must be developed should be carried out by staff of the local Health Unit to maximize the phosphorus retention capabilities of the natural soil and vegetation on the lot;

b) new proposed development should be planned on the basis of a 100-foot setback of septic tank and tile field systems from shoreline. As parts of some lake shorelines with steep slopes offer no retention of nutrients from tile bed systems, the upper edge of these slopes where land levels off should be considered the start of the 100-foot setback distance;

c) fill material used for the installation of the tile field systems should be of a reasonably fine nature to encourage the retention of waste materials such as phosphorus;

d) clearing of the vegetation on lots during development, especially between the tile bed site and the shoreline should be minimized.

General Recommendations

1. It is recommended that cottagers ensure that their sewage disposal systems are functioning properly and meet provincial standards.

2. Shoreline aquatic weeds should be mechanically harvested whenever possible rather than chemically treated. Permits for chemical treatments of aquatic weeds must be obtained from:

   The District Pesticides Officer,
   Peterborough District Office,
   139 George Street North,
   Peterborough, Ontario

   (Tel: 743-2972)

3. Participation in the chlorophyll *a* - Secchi disc Self-Help Program is encouraged to aid in assessing long-term trends in the water quality of the area lakes. For further information, contact staff of the:

   Technical Support Section,
   Central Region Office
   150 Ferrand Drive
   Don Mills, Ontario

   (Tel: 424-3000)

SUMMARY

Through a joint program between the Seven Links Planning Board and this ministry, a water quality survey of 17 waterbodies in the Planning Area was carried out during 1978.

The water quality of lakes in the study ranged between unenriched waters such as Methuen Lake and Oak Lake to very enriched waters like the Trent River at Hastings and Lower Stony Lake.

Lakes were ranked in order of their relative sensitivity to further unrestricted shoreline development and further divided into groups. Lakes considered most sensitive were Sandy, East and West Twin, Oak, Jack, Kasshabog and Lost. Lakes considered moderately sensitive to further unrestricted shoreline development were Long, South, Methuen and Upper Stony. Lakes considered Least Sensitive were Round, Dummer, Belmont, Cordova, Crowe, Lower Stony and the Trent River.

Recommendations for further shoreline development relating to each group of lakes were made as well as some general recommendations.

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Appendix I Calculation of Flow from Dummer Lake 1978

According to staff of the Trent-Severn Waterway office, the flow through the Gilchrist Bay dam into Dummer Lake was about 1.1 to 1.7 m^3/sec (40-60 cfs) depending on water level, with some overtopping of the dam in the spring of 1978. This flow was estimated for each month and additions for immediate drainage basin flow and overtopping were also made. The resulting flows for each month were as follows:

Month	Estimated Flow (x 10^6 m^3)
Jan	3.033
Feb	2.740
Mar	4.550
Apr	4.403
May	4.929
Jun	3.669
Jul	3.033
Aug	3.033
Sep	2.935
Oct	3.791
Nov	3.669
Dec	3.033
TOTAL	42.818

Appendix 2 Crowe Lake Flow Calculations

Mean monthly flows for Station 02HK006 on Beaver Creek were substracted from Station 02HK003 on the Crowe River to obtain a mean flows at the outlet of Crowe Lake. The annual discharge was applied to other subwatersheds in the Planning Area to estimate the discharge at each lake outlet. When necessary, the monthly flow was proportioned from the percent of total flow for Crowe Lake during that month.

Month	Crowe L. outlet instantaneous flow (m^3/sec)	Crowe L. outlet for month ($x10^6 m^3$)	Percent of year flow
Jan	22.60	700.6	10.4
Feb	20.74	580.7	8.6
Mar	14.83	45.7	6.8
Apr	54.52	1635.6	24.2
May	51.31	1590.6	23.5
Jun	9.04	271.2	4.0
Jul	1.89	58.6	0.9
Aug	2.02	62.6	0.9
Sep	5.52	165.6	2.4
Oct	9.01	279.3	4.1
Nov	14.13	423.9	6.3
Dec	17.19	532.9	7.9
mean	18.57		

Appendix 3 Calculation of phosphorus budget

Supply from land drainage in a tributary lake

Using the revised total phosphorus export value for a forested igneous watershed ($E = 5.5\ mg/m^2/yr$) from Dillon (1978).

J_E (phosphorus supply from the land drainage) = Ad X $E/10_6$

Supply from land drainage in a downstream lake

Using measured total phsophorus concentration from inflow stations and estimated monthly flow, the monthly export of phosphorus to the lake was calculated for May to October. For other months the following assumptions were made:

1. March and April total phosphorus concentration was the same as for May;

2. January, February, November and December were similar to mean value.

The data from available monitoring stations in the area appeared to support this pattern.

e.g. flow for month (m^3) X total phosphorus concentration $\frac{mg}{m^3}$ = export of P (mg)

$$\frac{\text{yearly export of P (mg/yr)}}{\text{Drainage area } (m^2)} = \text{E calc. } (mg/m^{-2}/yr)$$

Supply from precipitation

Using a revised figure for the total phosphorus loading of 50 $mg/m^2/yr$ (Dillon, 1978)

J_{PR} (phosphorus supply from the atmosphere to the lake) $= 50 \times Ao/10^6$

Phosphorus input from shoreline development

It was assumed that the phosphorus export from each cottage was 0.4 Kg/yr. This figure appears realistic for management purposes as it is below Dillon's estimated figure of 0.61 Kg/cottage which assumes that no phosphorus is retained in the septic tank and tile field and above the figure of 0.28 Kg/cottage which Nicholls (1976) calculated as the amount of phosphorus seeping into Harp Lake. It was assumed that a permanent residence had an average occupancy of 4.3 persons and that the sewage disposal system removed 80 percent of the total phosphorus before it reached the lake. It was also assumed that each tent and trailer site had a net phosphorus export of 0.2 Kg/yr.

e.g.	J_A cottages	$= 0.4 \times 434$	= 174 Kg/yr.
	J_A perm. residence	$= 4.3 \times 0.8 \times 0.2 \times 21$	= 15 Kg/yr.
	J_A camp	$= 0.2 \times 100$	= 20 Kg/yr.
	J_A existing		= 209 Kg/yr.

Appendix 4 Calculation of total phosphorus concentration index of change

Using the formula of Dillon (1975) to calculate spring phosphorus concentrations, the concentration for existing conditions was subtracted from the concentration assuming 100 more shoreline cottages with no special restictions (i.e. 40 Kg more supply).

$$[P] = \frac{L(1-R)}{\bar{Z}.p}$$

where $L = \dfrac{\text{the total phosphorus supply}}{\text{lake surface area}} \left(\dfrac{mg}{m^2 yr}\right)$

R = phosphorus retention coefficient

$\bar{Z}$ = mean depth (m)

P = flushing rate (yr^{-1})

$$[P]_{+100} - [P]\ \text{existing} = \text{index}$$

Appendix 5 Index of total phosphorus concentration change

Lake		$[P]_{+100} - [P]$ (ug/l)
Belmont		0.1
Cordova		0.1
Crowe		0.0
Dummer		0.6
Jack	- North	0.4
	- South	0.3
Kasshabog		0.3
MacDonald		2.1
Long		3.0
Lost		4.2
Methuen		1.5
Oak		1.2
Round		0.3
Sandy		4.3
South		2.2
Twin	- East	
	- West	5.2